ENERGY AUDIT ON A DYRER IN A LOCAL CERAMIC INDUSTRY

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The project report attached here, entitle 'Energy Audit on a Dryer in a Local Ceramic Industry' prepared and summated by DOMINIC BECHAT NANANG as a partial fulfillment of the requirement the Degree of Bachelor of Engineering with Honours (Mechanical Engineering and Manufacturing System) is hereby read and approved by:

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AUDIT TENAGA TERHADAP PENGERING DI INDUSTRI SERAMIK TEMPATAN

DOMINIC BECHAT NANANG

Projek ini merupakan salah satu keperluan untuk Ijazah Sarjana Muda

Kejuruteraan dengan Kepujian

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Abstract

Presently, many factories in the world are applying the energy audit to maximize the profit that they would get. The ceramic manufacturing industries are an energy-intensive industry. This report discussed how energy audit can reduce the energy cost in the local ceramic industry. The focus is on the Sarawak ceramic manufacturing industry.

The ceramic industry consumes much energy. The ceramic industry also noted for great percentage of the energy cost in a total production cost. In the ceramic industry, appreciable amount of energy could be saved or conserved by preventing of leakage in the dryer and modifying the equipment to recover heat from the dryer in the process of ceramic- drying. Thus, energy audit are conducted by using heat balance technique to know where the leakage and product much heat loss

The result shows that much energy loss from two main areas, exhausted gas and from conduction and radiation. In real condition, mostly heat loss created by waste heat. Due to insufficient data this matter have to be neglected but improvement can be made by using one type of heat recovery system (HRS) namely counter-flow recuperative heat exchanger (CRHE).

Abstrak

Pada masa kini, banyak kilang-kilang di seluruh dunia mengaplikasikan pengauditan tenaga.untuk meningkatkan lagi keuntungan yang diperolehi.Di dalam pembuatan seramik terutamanya dalam penghasilan jubin memerlukan tenaga yang banyak dan ia melibatkan proses- proses yang rumit, Di dalam buku laporan ini akan diterangkan bagaimana pengauditan tenaga dapat mengurangkan kos tenaga yang digunakan dalam industri seramik tempatan.Fokus utama adalah industri pembuatan seramik di Sarawak.

Industri pembuatan seramik menggunakan banyak tenaga. Ia juga terkenal sebagai penyumbang terbanyak peggunaan tenaga dalam keseluruhan kos pengeluaran. Di dalam industri pembuatan seramik, jumlah tenaga dapat dijimatkan dan diserap dengan menghalang kebocoran di dalam pengering dan mengubahsuai peralatan yang digunakan untuk memperolehi kembali haba dari pengering semasa proses pengeringan seramik berlaku.Dengan demikian, pengauditan tenaga diaplikasikan dengan menggunakan teknik imbangan haba untuk mengetahui dimana kebocoran berlaku dan dimana tempat yang menghasilkan banyak kehilangan haba.

Daripada keputusan yang diperolehi, jelas menunjukkan kehilangan haba berpunca dari dua kawasan, gas ekzos dan dari pengaliran haba dan radiasi. Di dalam situasi sebenar, kebanyakan kehilangan haba dihasilkan oleh pembaziran haba. Disebabkan kekurangan data, hal ini terpaksa diabaikan tetapi peningkatan dapat dilakukan dengan menggunakan salah satu jenis ‘Heat Recovery System (HRS)’ iaitu ‘Counter-Flow Recuperative Heat Exchanger (CRH)’

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Nomenclature

Symbol	Description	Unit
A	Cross-sectional area	m^2
$\mathbf{C_p}$	Specific heat	kJ/kg.K
$\mathbf{T_1}$	Inlet temperature of the dryer	K
$\mathbf{T_2}$	Outlet temperature of the dryer	K
Q	Heat	kJ
V	Velocity of exhausted air	m/s
$\boldsymbol{\sigma^2}$	The population variance	-
$\boldsymbol{\sigma}$	The population standard deviation	-
x	The item or observation	-
$\boldsymbol{\mu}$	population mean	-
n	Total number of items in the population	-
P	Pressure	mm.C.A
$\boldsymbol{\eta}$	Dryer Efficiency	%

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

Saving money on energy bills is a very desirable result to industries and individuals alike. Industries, whose energy bills represent a substantial fraction of their company's operating costs, have a strong motivation to initiate and continue an on going energy cost control program. Small changes of operation cost can often save a customer or an industry 10-20% of their utility bills (TÜV Süddeutschland India, 2001). Capital cost programs with payback times of two years or less can often save an additional 20-30 %(TÜV Süddeutschland India, 2001). In many cases, these energy cost control programs will also result in both reduced energy consumption and reduced emissions of environmental pollutants such as SOx, WOx, NOx.

An energy audit is one of the first steps to be performed in the accomplishment of an effective energy cost control program. The energy audit consists of a detailed examination of how a facility uses energy, what the facility pays for that energy, and finally what are commended program for changes in operating practices or energy consuming equipment that will reduce energy bills.

The industrial sector is the largest consumer of energy, consuming about half of the total commercial energy consumption in 1999/2000(D.O.E, U.K, 2000). Coal and lignite meet over half of industrial commercial energy requirements. The transport sector is the next biggest consumer at 22% of total commercial energy consumption (D.O.E, U.K, 2000). Thus, the industries in United Kingdom should make efforts to reduce their energy consumption by conducting energy audits.

Industrial Energy Audit is an effective tool in defining and pursuing comprehensive energy management program. The scope of energy management such as planning, decision-making, organizing and controlling apply equally as in any other management subject. These functions can be effectively performed, based on the reliability of data/ information provided to the energy auditors.

Effective management of energy-consuming systems can lead to significant cost and energy savings as well as increased comfort, lower maintenance costs, and extended equipment life.

1.2 Objective

The three main objectives of this study are:

1. To do energy audit on a dryer in a ceramic manufacturing plant.
2. To determine the efficiency of the dryer operation.
3. Suggestion for improvement in the dryer operation.

1.3 The fundamental of drying in ceramic industry

During the manufacturing of ceramic, the drying process usually involved the removal of water from clay. The presence of water allows the desired shape to form by giving the clay fraction the necessary plasticity. The moisture content ranges from 5 – 7% for dust-pressed items to 30 – 40% for slip casting (Energy Efficiency Best Practice Programme, 1995).

Three efficient and effective drying, three separate-but ideally simultaneous-processes should occur,

i. Transfer of heat to the drying article,
ii. Vaporization of liquid water within the article,
iii. Removal of water vapour from the vicinity of the dryer.

Due to high latent heat of vaporization of water, the drying process has a potential to use large amounts of energy. Table below shows the relative use of energy for drying by the various sectors of the UK ceramics industry in 1995.

Table 1.1 Energy use in the United Kingdom ceramics industry in 1995

(Source: www.ceramic industry.org.uk.)

Sector	Drying(TJ/year)	Total(TJ/year)	% used for drying
Tableware	1030	5887	17.5%
Tile	420	2997	14.0%
Sanitary ware	437	2657	16.4%
Refractory	632	7026	9.0%
Non-fletton bricks*	8224	17890	46.0%
Total	10743	364578	29.5%

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11% of the heat used for drying is direct fuel use

Energy for drying is often used inefficiently. Simple no cost and low cost energy saving measures are available that could significantly reduce energy consumption for drying. For example, companies can typically save 10% of their energy costs through improved energy management and good housekeeping measures (Energy Efficiency Best Practice Programme, 1995).

1.3.1. Theory of Drying

The drying behavior of a product depends on:

i. The shaping characteristics.

A shaped ceramic product can be thought of as a porous structure formed by particles between which there are interconnecting cavities, spaces and channels of various shapes and sizes. The physical dimensions, orientation, quantity and distribution of these spaces depend on the manufacturing process and the shaping method employed. Drying involves water passing through these various channels to the surface of the piece and being removed by evaporation.

ii. The operating parameters of the drying process.

The rate of the drying is controlled by:

a) temperature- the higher the temperature, the greater the rate of the drying,
b) relative humidity- the higher the humidity, the slower the rate of drying,
c) airflow- the higher the rate of airflow, the greater the rate of drying.

Design features such as the product's surface area and thickness can also influence the rate at which a particular product can be dried.

These various factors are used to shape the drying curve to the ideal drying conditions for a product. For an energy efficiency drying system, the aim is, as far as possible, to dry the product from the inside and not from the outside. The drying of ceramic products typically take place over three discrete phases. During each phase, the rate of drying, water removal and shrinkage are different as detailed below:

i. **Phase one**

During the first phase of the drying cycle, the aim is to achieve a low rate of water removal from the surface. This reduces moisture gradients across the piece and thus minimizes the risk of breakage and deformation.

As water is removed from the product, the clay particles move towards each other. This restricts the natural capillaries and channels through which water moves during the evaporation phase. As these ‘escape routes’ close, the resistance to the water flow increases and the rate of water removal from the centre of the product decreases. To minimize this problem, the ideal drying conditions for the first phase of drying are low temperature, high humidity and low airflow.

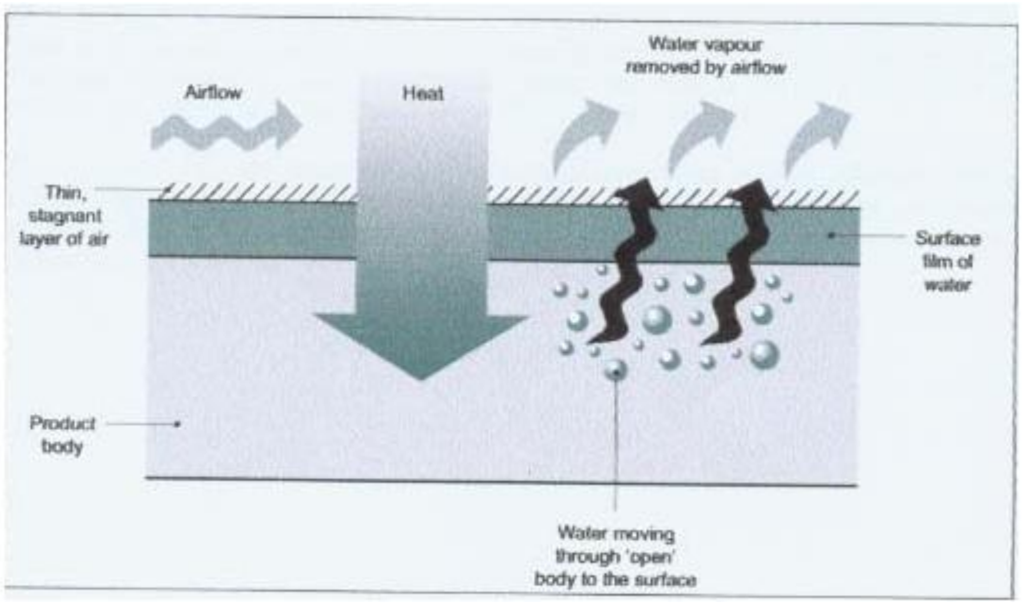

Figure 1.1 First phase of drying

(Source: [http://www.energy-efficiency. uk.my](http://www.energy-efficiency.uk.my))

ii. Phase two

As drying proceeds, the spaces between the particles contract and become filled with either air or water vapor. The process continues until all the particles touch. The retreat of the surface film of water to within the product causes the color and physical nature of the surface to change. The product becomes rigid and loses its initial flexibility. As shown in figure 1.1, during this phase of the drying cycle, a slow increase in temperature, slow decrease in humidity and an increase in airflow over the product's surface are necessary.

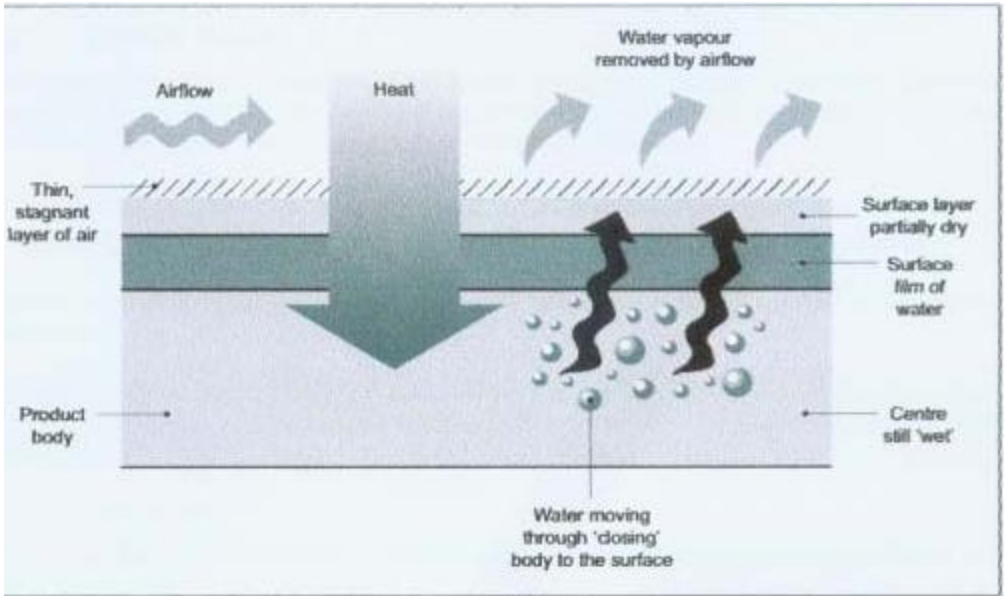

Figure 1.2 Second phase of drying

(Source: http://www.energy-efficiency. uk.my)

Although the surface layer of the product may have stopped shrinking, it could still be quite wet inside. This results in a build-up of strain as this interior moisture tries to escape. The moisture gradient between the outside and the inside of the product places limitations on the rate at which water can be removed without cracks developing. The degree of cracking depends on the stresses to which the surface is subjected and on the ability of the clay to withstand them.

iii. Phase three

Once all the particles are touching, no further shrinkage is observed. The piece has reached its final linear dimension, the pores in the structure being filled with water. At this point, the risk of breakage falls significantly and a faster rate of drying can be employed.

The last water to be removed is that from between adjacent particles. The rate of drying steadily decreases as water vapor is formed and migrates to the surface from places further and further away from the surface of the product. During this phase, the temperature and rate of airflow can increased to maximum

1.4. Introduction to manufacturing process of ceramics

Naturally occurring inorganic substances are heat-treated after adjustment of the grain size and moisture, and some of them are completely molten to be formed into ceramics; while others are formed, heat-treated and made into the ceramic products in the sintered state immediately before being molten. The former product formed in the molten state is known as glass, and the latter product finished in the sintered state includes pottery, refractory, sanitary ware, tiles and cement. These ceramics are called traditional ceramics. By contrast, extremely fine particles of high-purity are sintered at a high temperature and made into ceramics; they are called advanced ceramics. These advanced ceramics are used in electronic parts and mechanical parts. The following describes the traditional ceramics production process: